Study of Revolutionary Earth Sciences Architecture for Atmospheric Chemistry, Earth Radiation Balance, and Geomagnetism Measurements

RASC Mid-Term Review

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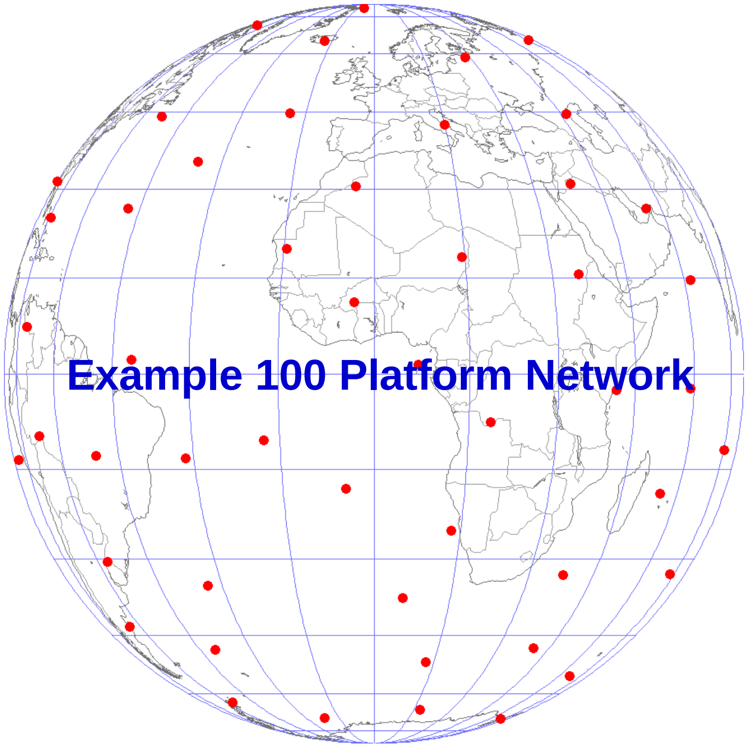
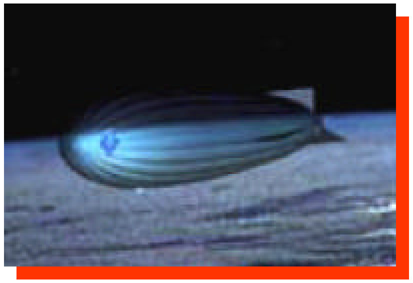
Study of Revolutionary Earth Sciences Architecture

- NASA Study PI - Warren Wiscombe/GSFC Code 972
- NASA Study Manager - Chuck Williams/GSFC Code 850
- Identify suitable platform(s) for future revolutionary stratospheric *in-situ* measurements





Study of Revolutionary Earth Sciences Architecture

- Identify long-duration, autonomously coordinated in-situ measurements that can be made from the stratosphere (20 - 35 km)
- Platforms must be able to survive and operate in the stratosphere for more than 100 days, autonomously gather and relay data, be able to understand and correct their position with respect to other platforms, and notify project control in case of a problem
- Global coverage would require on the order of 100 platforms
- Desired Scientific Observations:
  - Atmospheric Chemistry
    - Stratospheric vertical profiles of trace gases Cl_y, No_y, Br_y, H, O_3
  - Earth Radiation Balance
    - Upwelling shortwave (0.2 to 3 μm wavelength) and longwave (4 to 50 μm) radiation flux
  - Geomagnetism
    - Scalar and vector components of Earth's magnetic field

Status

- Submitted FY03 RASC proposal to fund 2nd year of study
- Study Contractor has submitted a report linking the study science themes to NASA Earth Science Enterprise (Code Y) Research Strategy
- Earth Science Working Group (ESWG) has been established
  - Atmospheric Chemistry - Dr. William S. Heaps
  - Geomagnetism - Dr. Michael Purucker
  - Earth Radiation Balance - Prof. Zhanquing Li, Chair
- Dr. Albert Arking, Co-Chair

Status (cont.)

- ESWG Workshop was held at Greenbelt Maryland June 19, 2002
  - Attended by 22 scientists from various U.S. Government agencies and academia, and from Russia
  - Significant science objectives identified and potential applications envisioned (see backup charts)
- Study Contractor has submitted a preliminary assessments of the science, discussed at the workshop, and the identified advantages in employing stratospheric platforms (see backup charts for more detail)
- Study Contractor has submitted information, concerning the study, to be posted on the RASC website

RASC

Status (cont.)

- Candidate platforms capable of performing scientific observations from the Stratosphere have been identified and the evaluation criteria developed (see backup charts)

- Currently available platforms compared with stated revolutionary platform capabilities:

Current Earth Science Platforms	Mission Duration	Payload Capability, kg	Typical Altitude, km	In Situ Measurements (20-35 km)	Power to Instruments, W
Polar Sun Sync.Satellites	10-years	200-800	800	No	200-1000
Moderate Incl. Satellites	10-years	200-800	500	No	200-1000
Stratospheric Balloons	3-10 days	2000	35	Yes	600-1000
Stratospheric Balloons - Polar	10-33 days	1000	35	Yes	600
IR Balloons	20-70 days	10	17-28	No	50
Stratospheric Aircraft	<1 day	860-1650	20	No	1300-7000
Radio/Drop Sondes	*2 hours*	*0.1*	*Radio to ~30 Drop from 20*	*Yes to ~30 (Radiosondes)*	*0.05*
Revolutionary Earth Science Platform	100 days to 1 year	200 or more	30-35	Yes	1000

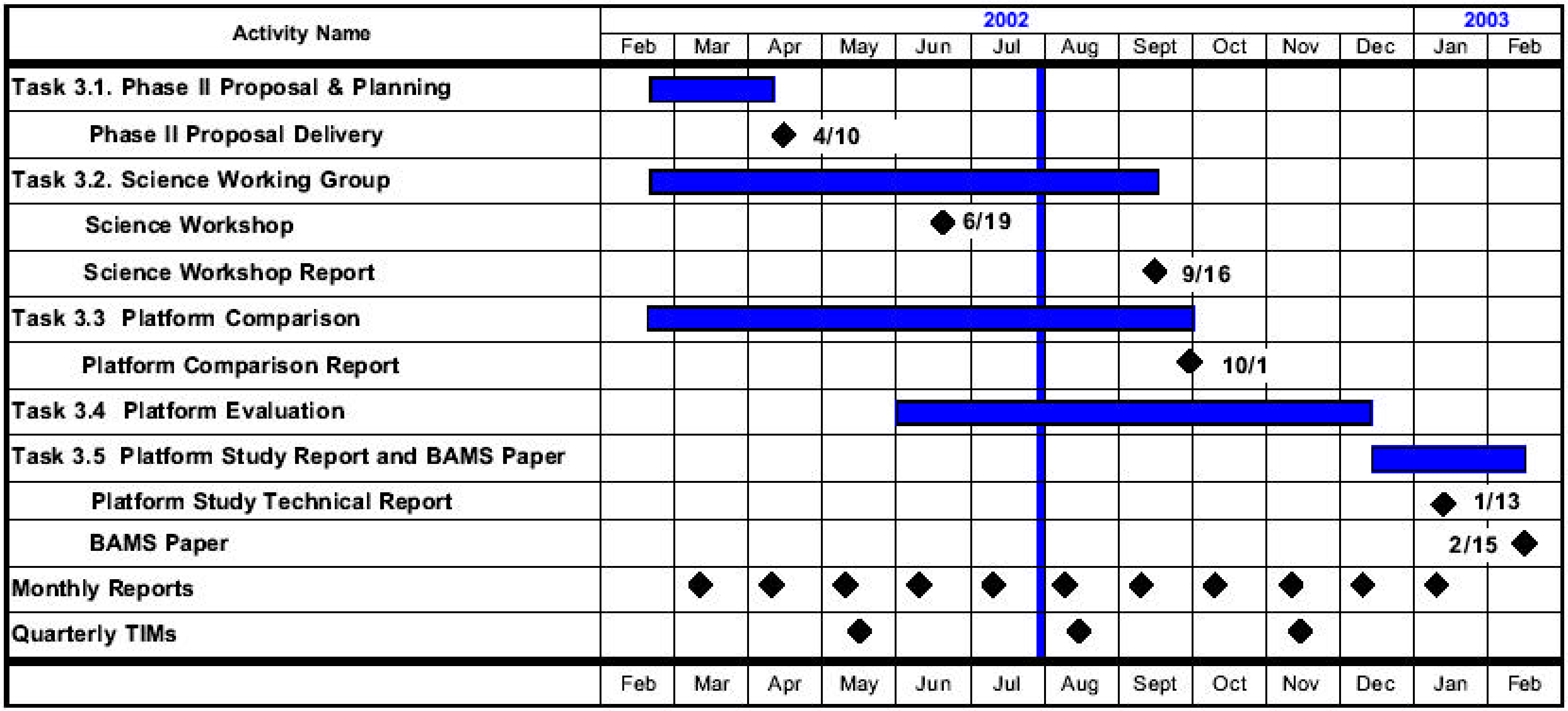
CURRENT PLATFORM COMPARISON

- Light blue shading indicates match of current platform with stated capability
- Note, no single current platform meets stated capabilities of revolutionary platform

Planned Contractor Activities

- Review input received at the workshop and begin development of a detailed workshop report
- Continue comparing stratospheric platforms as related to the requirements developed at the workshop
- Start work on platform evaluation using the performance requirements obtained at the workshop
- Refine Science Mission Possibilities (linked to Code Y Research Strategy)
- Start work on the Final Report and the BAMS article

Schedule for RASC Study of Revolutionary Earth Sciences Architecture



Expected Dates of Completion

- The ESWG Workshop report will be submitted by September 16, 2002
- The Platform Comparison Report will be submitted by October 1, 2002
- The Platform Study Technical Report will be submitted by January 13, 2003
- The BAMS paper will be submitted at the end of the study period (February 15, 2003)

Issues and Concerns

- The Study Contractor has requested a no-cost extension for this activity
  - Study completion date has been extended from December 15, 2002 to February 15, 2002
  - Funding arrived at GSFC later (February 2002) than the scheduled study start date (December 2001)
- The selection date for RASC FY03 studies has been delayed
  - If FY03 proposal is selected, will funding arrive late as did FY02 funds?
  - Break in funding may disrupt synergy of study
    - Next phase to identify technologies necessary for platform to make the desired measurements

Backup Charts

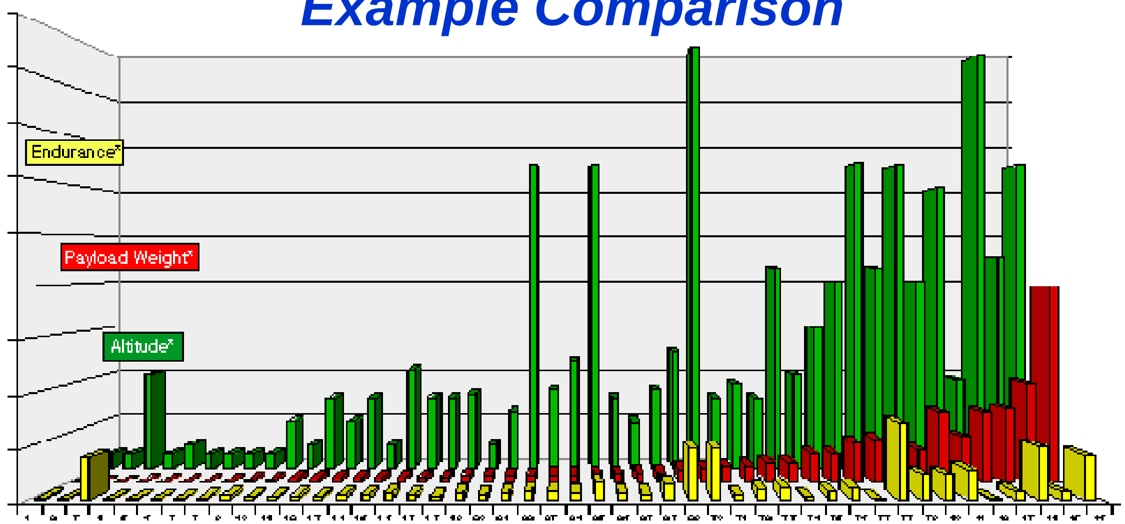
Platforms Classes Identified for Comparison and Example Current Platforms

- Crewed Aircraft
  - ER-2, U-2, WB-57F, Mig-25, Proteus
- Unmanned Aerial Vehicles (UAV)
  - Global Hawk, BQM-34 Firebee, Helios, Predator, UltraLEAP
- Balloons
  - Zero Pressure, ULDB, GAINS Anchor - GSSL
- Airships/Blimps
  - Sounder – SRI, Stratsat - ATG

Platform Evaluation Criteria - 1

- Meets science requirements
- Payload capability
  - Size or performance
  - Altitude
  - Duration
  - Range
  - Speed
  - Power availability

Example Comparison

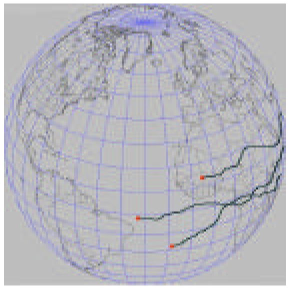


- Gross platform size and mass
  - Larger systems carry more payload and cost more
- In situ measurement ability
  - Too slow or too fast
  - Vertical velocity

Platform Evaluation Criteria - 2

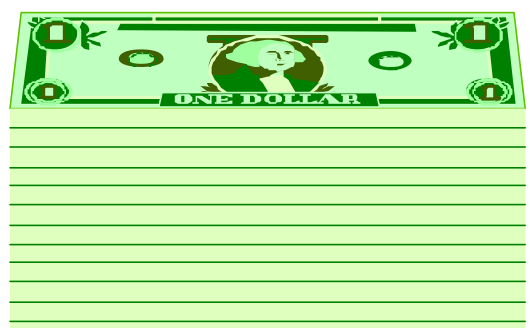
- Launch, operations and payload recovery
  - Launch complexity
  - Weather and seasonal limitations
  - Solar illumination
  - Facilities needs
  - Air traffic control limitations
  - International overflight
  - Human, property and payload safety requirements
  - Landing site geography

- Flight path control
  - Position and attitude control requirements
  - Seasonal and latitudinal wind effects e.g. station-keeping
  - Formation and network control ability



Platform Evaluation Criteria - 3

- Reliability
- Airborne life-limiting factors
  - UV degradation of materials
  - Consumables
  - Hardware failure
- Life-cycle costs
  - Platform research, development and testing
  - Recurring and replacement
  - Operations and disposal



Desired Stratospheric Platform Capabilities

- 30-35 km constant altitude
- 100 day flights (eventually extending to 365 days)
- 1 kw of power
- 200 kg or more payload capacity
- Payload recovery at end of flight

Potential Benefits offered by Stratospheric Platforms

- Low-cost, high-altitude (35 km) platform above 99% of Earth's atmosphere
- *In-situ* measurements eliminate assumptions inherent in remote sensing of same quantity
- Long-life platform provides high accuracy (through averaging) if errors are random
- Continuity of long-term climatological observations
- Instrument recovery allows post-flight verification
- Easy upgrade to new technologies: recover and re-launch
- Validation of space-borne instruments

Earth Science Working Group Workshop Group Results

Atmospheric Chemistry

- *Science Questions*
  - Why ozone in midlatitudes is reducing?
  - What controls water content of the stratosphere and how it is changing?
  - What is the budget of green house gases in the atmosphere? Why CO_2 budget is not balanced?
  - What are the budgets of air pollutants (like ozone)?

- *Advantages Using Stratospheric Platforms*
  - High-resolution *in-situ* measurements
  - *In-situ* validation of satellite measurements
  - Higher resolution and S/N of remote sensing instruments
  - 100 day flight would provide snapshot of evolving stratospheric trace gas structure

Earth Science Working Group Workshop Group Results

Earth Radiation Balance

- ***Science Questions***
  - What are the dynamics of the Earth radiation balance?
  - How atmospheric temperature, moisture, clouds and aerosols affect radiation budget at top of the atmosphere?
  - What are regional and far-reaching impacts of stratospheric natural events on climate?
  - What are the "laws" of bi-directional reflectance?

- ***Advantages Using Stratospheric Platforms***
  - No radiance to flux conversion (satellites measure radiance)
  - *In-situ* satellite validation
  - Anisotropic characteristics, spatial and temporal coverage not possible from satellites
  - 100 day platforms around the globe would measure flux directly and provide dynamics

Earth Science Working Group Workshop Group Results

Geomagnetism

- ***Science Questions***
  - What is the nature of the middle and lower crust?
  - How the South Atlantic magnetic anomaly changes?
  - What is the sub-ice circulation in Polar regions?
  - How natural hazards depend on crustal deformation and faulting?

- ***Advantages Using Stratospheric Platforms***
  - Observations at stratospheric altitudes allow to separate various components of Earths magnetic field
  - Add intermediate spatial wavelength information to existing surface and satellite surveys
  - Long term coverage over hard to access sites
  - Space weather events warnings for polar satellites